Tactual Discrimination of Shapes

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Abstract

The young child's development of the concept of space was explored utilizing shapes characterized by topological and Euclidean relations. The subjects were required to tactually explore a stimulus shape and then to locate the identical shape tactually from among four alternatives. No significant differences were found on the basis of vision or sex, but school experience did affect choice. Results were examined in terms of Piaget's theory of spatial development and found to parallel his findings with sighted children.

Tactual Discrimination of Shapes

Previous work in the series of research studies involving the young blind child's development of the concept of space has provided a theoretical overview of spatial concepts (Simpkins, 1978a) and a study of the young blind child's tactual discrimination of objects (Simpkins, 1978b). In the latter, common household objects were tactually presented to blind, partially sighted, and sighted children. They were required to identify the same or similar object as the stimulus from among three alternatives. Results indicated no differences were found between the type of identification (same or similar) required, and the room categories (utility, living or family, bath, etc.). These results suggested that exploratory activity was modified by experience since subjects with 1 year of schooling performed better than subjects with no previous school experience. Coding stimulus information played an important role in the tactual identification of the objects while the significant differences in performance on the basis of room classifications suggested greater familiarity with some areas of the home. Shapes were studied in the next phase of these studies to determine whether the variables affecting tactual discrimination of household objects affected performance on tactual discrimination of abstract shapes, also.

In studies conducted by Piaget and Inhelder (1965) and replicated by others (Bass, 1975, pp. 45-70; Copeland, 1974, 1976; Flavell, 1963; Larendeau & Pinard, 1970; Sauvy & Sauvy, 1974), the spatial concepts

examined through shape recognition were found to follow the mathematical development of spatial notions, but in reverse order. This meant that topological relations were understood prior to projective or Euclidean ideas.

In topological mathematics, figures are not considered to be fixed or rigid in shape. Rather they may be squeezed or expanded until they assume a different shape. The first topological spatial relation to develop is proximity or "nearbyness." The younger the child is the more importance this property assumes. The next relationship to develop is that of "separation" or distinction of one object or parts of that object from another. As the child builds on the ideas of proximity and separation, she/he develops the property of order. Finally, an element is recognized as being not only between other elements in a series, but also enclosed or surrounded by those other elements. This is the spatial relation of enclosure or surrounding. These notions of space are not fully integrated into the child's system of mental operations until approximately 7 to 8 years of age (Bass, 1975, pp. 45-70; Copeland, 1974; Flavell, 1963; Piaget & Inhelder, 1965; Sauvy & Sauvy, 1974; Simpkins, 1978b).

Piaget's findings were supported by several replication studies with qualifications introduced through examination of additional variables. For instance, socioeconomic climate was found to influence the development of the concepts of order and enclosure in kindergarten through second grade children (Bass, 1975, pp. 45-70). A sex influence

was noted in a study of the concept of limit when only male responses rated in the highest performance category (Mitchelmore, 1976, pp. 143-184; Taback, 1975, pp. 111-144). Age influenced the representations of spatial information in cognitive maps when adults utilized multi-level representations. The general level contained simple coordinated representations which held between objects while the specific level contained a series of smaller representations associated with particular points of view (Hardwick, McIntyre, & Pick, 1977). Piaget also found young children unable to describe a neighborhood as a whole because landmarks were placed in subgroups based on independent vantage points used by each child. Thus, the early spatial representations in cognitive maps were influenced by topological relations.

Spatial concept research resulting from studies with sighted children has suggested some teaching and training methods (Copeland, 1974, 1976; Kamii, 1971, pp. 281-344; Lovell, 1971, pp. 104-117; Sauvy & Sauvy, 1974). Four instructional objectives for structuring space were suggested by Kamii (1971, pp. 281-344). First, the notions of "in-out," "over-under," "in front of-in back of," etc. were grasped not only in terms of the child's own body, but also on a representational level with toys, pictures, and finally, words. Secondly, linear order involved the ability to coordinate proximity relationships in order to copy the placement of objects. This placement could be accomplished in the same linear arrangement, with the objects either grouped closer together or spread farther apart than the model,

or in an inverse order. Thirdly, spatial transformations such as cutting a whole into parts and putting it back together were practiced. Finally, the child was encouraged to reconstruct his/her sensory-motor knowledge of space on a representational plane. After describing each assessment used by Piaget in examining the child's notion of space, Copeland (1974, 1976) suggested ways a teacher might conduct similar experiments and how the results might be interpreted. Classroom activities were then presented which would promote development of these concepts. Sauvy and Sauvy (1974) directed attention to games such as hopscotch and other activities that children engage in which support spatial concept development.

Although knowledge of spatial concepts development has been accumulating, these data have been based primarily on studies conducted with sighted individuals. The blind child's concepts of space and how she/he organizes or mentally represents that space has not been studied extensively and has generally been inconclusive. Tactual perception requires successive operations (actions) within the restraints of spatial relations for recognition. To form a conclusion on the basis of these operations, the individual must tactually observe, systematize the actions, and finally, merge the resulting reactions. It was hypothesized, therefore, that topological relations would play an important role in the tactual recognition of shapes in young blind children.

Purpose

Acknowledging the lack of available information on the development of spatial concepts in young blind children, the present study attempted to identify some of these concepts by tactual recognition of shapes. Through this means, the topological relationships used by sighted children were compared with those employed by blind children.

Method

Subjects

Blind and partially sighted children enrolled in both public and private school classes as of September 1, 1977, were included in the sample if they had no severe handicapping condition (other than visual impairment), had either no previous school experience or only 1 year of schooling, and were between the ages of 4 to 7 years. Blind and partially sighted subjects were selected from classes in the Philadelphia Public Schools; Overbrook School for the Blind; Southern New Jersey; Delaware; Montgomery County, Maryland; Indiana School for the Blind; Kentucky School for the Blind; Cleveland, Ohio Public Schools; and Nebraska School for the Blind as well as students in various day school programs in Nebraska. Sighted subjects were randomly selected from kindergarten and first grade classes in a Philadelphia Public School. Table 1 presents a summary of the sample.

Insert Table 1 about here

Because of the difficulty in locating blind subjects who met age, prior school experience, and nonhandicapped condition requirements, it was inferred that differences among groups on the basis of age might result. A series of *t* tests indicated that no significant differences existed among ages of the subsamples (see Table 2).

Insert Table 2 about here

Materials

The Topological Shapes Assessment used to study the child's notions of topological and Euclidean understandings of space included those shapes utilized by Larendeau and Pinard (1970). The forms were cut from 1/4 inch thick masonite in the dimensions specified in the Larendeau and Pinard (1970) study. Part A of the assessment involved simple, more familiar shapes while Part B contained more complex shapes requiring greater differentiation between topological and Euclidean understandings (see Figure 1).

Insert Figure 1 about here

Procedure

Each subject was seen individually for approximately 30 minutes. Initially, a preliminary task was administered to acquaint each subject

with the procedure used in the assessment. This task also indicated whether the child was able to differentiate the concepts of same and different. If there was confusion of these terms, the task was used to teach the concepts. Only when the child met criterion (3 out of 4 on procedure 1, 4 out of 5 on procedure 2, and 3 out of 4 on procedure 3) on the preliminary task was she/he included in the sample. Following the preliminary task, the screening box was introduced and the subject was given opportunity to become familiar with it. The box consisted of three sides and a top with cloth sleeves in the side facing the child. The experimenter sat opposite the child and presented the stimulus for tactual exploration through the open side. A work-play tray with styrene divider was used for placement of the four options. From these alternatives the child identified the same shape as the stimulus.

Design

The construction of the Topological Shapes Assessment was less involved than that for the objects in Household Objects Familiarity Assessment (Simpkins, 1978b). Through review of studies utilizing tactual discrimination of shapes (Bass, 1975, pp. 45-70; de la Pena, Hirsch, & Eisenson, 1973; Dershowitz, 1973; Larendeau & Pinard, 1970; Piaget & Inhelder, 1965; Schneiderman, 1971), it was decided that the extensive work of Larendeau and Pinard provided both a guide for conducting the study as well as analyses for comparative purposes. However, unlike their study in which the subject tactually explored

a stimulus and then visually identified its counterpart from among all 12 options, the present study presented both stimulus and alternatives tactually. Since tactual exploration of 12 options for each stimulus would have been a mammoth task for young children, four options were chosen for each stimulus. The options were defined and scored as follows: 1 designated the same shape as the stimulus; 2 defined a topologically similar shape; 3, termed a distractor shape, contained shapes with parts similar to the stimulus (e.g., stimulus - option); and 4 represented a shape whose properties were opposite or distinctly different from those of the stimulus (e.g., stimulus - option O). The order of presentation for items as well as the options within each item was randomly assigned using a table of random numbers.

Data were gathered on a pass-fail basis for recognition or non-recognition of the stimulus shape. Initially, analysis of variance techniques were applied to find whether there were differences between the three variables of degree of vision (blind, partially sighted, sighted), amount of prior school experience (0 years or 1 year), and sex (male-female) in the ability to identify simple (Part A) and then more complex (Part B) shapes. Relative difficulty was determined by compiling the number of successes for each shape by vision categories and school experience categories. The options were examined by definition to determine the type of errors subjects made in choosing a shape identical to the stimulus. This was

accomplished by tallying the number of choices made for each item by each vision group and by each level of school experience.

Results

Means and standard deviations for each subsample for total correct responses on the Topological Shapes Assessment are presented in Table 3. All subsamples of subjects did relatively well in tactual

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Insert Table 3 about here

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recognition of shapes (total correct score attainable for Parts A and B = 24); however, a difference between amount of previous schooling suggested a trend which was supported in the statistical analysis. Little difference was seen among vision subsamples and differences between sexes were contradictory between subsamples.

A 3 x 2 x 2 analysis of variance was performed on the total correct responses obtained on Topological Shapes Assessment (see Table 4). No significant differences were found for the main effects of vision

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Insert Table 4 about here

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or sex, but those who had 1 year of formal school experience performed significantly better than those with no previous schooling. A significant interaction also was found between degree of vision and amount of schooling. This was partially due to the low mean obtained

by blind female subjects with 1 year of schooling compared with the blind female subjects with no previous school experience. All other subsamples did indicate improvement of performance with 1 year of schooling. The significant effect of all three variables, however, was barely attained and may again be attributed to the irregular performance of the blind female group with 1 year of previous school experience and to the small number of subjects per cell (N = 4).

Relative difficulty was determined by compilation of the number of successes for each shape by vision categories, school experience groupings, and sex (see Tables 5 and 6). Using the total correct

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Insert Tables 5 and 6 about here

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responses for each item, the shapes were ordered by difficulty. A difference was noted in responses of subjects with no previous schooling and those with 1 year of school experience for Part A which contained simpler shapes typified by topological differences. However, the difference was not marked in Part B where both topological and Euclidean shapes were included (see Table 7).

Insert Table 7 about here

Comparison of the order of difficulty for the subsamples was made with Larendeau and Pinard's (1970) study. Table 8 presents these data.

The simplest (easiest) third of the shapes on Part A suggested the greatest similarity with the easiest third in Larendeau and Pinard's

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Insert Table 8 about here

(1970) study while for Part B the hardest and easiest third each showed considerably more overlap with the Larendeau and Pinard (1970) data.

To determine the types of errors made in choosing a shape identical to the stimulus, incorrect responses were examined by option definition (see Tables 9 and 10). Option 2, defined as a topologically similar shape, was chosen more frequently by all subsamples than

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Insert Tables 9 and 10 about here

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either options 3 or 4. Initially, blind subjects with no previous schooling made fewer errors than either the partially sighted or sighted subjects with no prior schooling (Part A: Blind = 24, Partially sighted = 31, Sighted = 33; Part B: Blind = 20, Partially sighted = 29, Sighted = 42). However, after 1 year of schooling, the blind subjects had a greater number of errors than either of the other two subsamples (Part A: Blind = 24, Partially sighted = 13, Sighted = 11; Part B: Blind = 30, Partially sighted = 16, Sighted = 11).

Discussion

Although few strong inferences may be made from the data because of the small sample size (N = 4 per cell) and the restricted range of scores, some conclusions suggest further avenues of research. Unlike previous studies involving spatial concepts, no differences were found between male and female performances (Mitchelmore, 1976, pp. 143-184; Taback, 1975, pp. 111-144). The differences found previously may be in part due to the older age of subjects and the difference in the types of tasks as compared to the present study. However, differences may develop as the child matures and advances into the concrete operational level of reasoning. This would be suggested by the significant difference in performance between those subjects with no previous schooling and those with 1 year of school experience since the latter were older as well as more experienced.

The data supported the results of other researchers (Ahmad, 1971; Ewart & Carp, 1963; Worchel, 1951) who found little difference among groups on the basis of degree of useful vision when only tactual recognition was required.

Significant differences were found between school experience groups for tactual recognition of shapes. This may be attributable in part to the teachings during the first years of school which frequently emphasize shapes (e.g., circle, square, triangle) and to the older age of those subjects with 1 year of schooling who would be beginning to make the finer discriminations of curvilinearity and rectilinearity.

The significant interaction noted between amount of vision and schooling, although primarily due to the schooling effect, was influenced by the strange performance of the blind females who performed extremely better without school experience. This, in conjunction with the sizable difference in the standard deviations within the groups for females with 1 year of schooling contributed to this interaction.

Relative difficulty on the Topological Shapes Assessment suggested that few shapes were of great difficulty for any of the subsamples for Part A though Part B created greater obstacles. The advent of Sesame Street and other such programs, early school training, and other influences (parental, older siblings, etc.) may be partially responsible for the greater tactual recognition of shapes by all groups.

The mean number of successes for ages 4 through 7 years was obtained for each item from the Larendeau and Pinard (1970, p. 50) study. These means were then used to rank order the items in terms of difficulty from hardest to easiest. For comparison, the mean successes for each item for the present subsamples were also used to rank the items from most to least difficult. The irregular cross and Greek cross were most difficult for all groups (appearing in the highest third of the ranking), while circle and open ring were the least perplexing on Part A. For Part B the trapezoid and irregular quadrilateral were the most difficult while circle and rectangle were easiest for all groups. These similarities persisted between vision

groups with no previous schooling as well as those with 1 year of schooling. However, when vision categories were collapsed, some differences in order of difficulty did appear between subjects on the basis of school experience. On Part A the difficult items remained relatively the same, but the simplest items differed. Those with 1 year of schooling found circle, square, and triangle simplest while children with no previous schooling found the open ring, open rectangle, and the disk with two holes easiest. The latter figures supported the conclusions of Piaget and Inhelder (1965) since these are all characterized by topological relations while those for the sample with schooling involved curvilinear-rectilinear relationships. Subjects with no previous school experience found the circle, triangle, and rectangle easiest on Part B while those with 1 year of schooling identified the rectangle, square, and Maltese cross as simplest. The latter shapes represented a finer distinction of the curvilinear-rectilinear relationship (i.e., square and rectangle) as well as beginning understanding of Euclidean concepts. These findings also suggested agreement with the conclusions of Larendeau and Pinard (1970). They stated that the distinction of curvilinear-rectilinear shapes was derived from Euclidean geometry but Piaget hypothesized that the distinction was formed first in the child who already discriminated topological relations. Lovell (1959) also found that the identification of curvilinear shapes was not much more difficult than that of topological shapes. However, discrimination of various

rectilinear shapes was more complex and appeared later. The results from the present study would seem to support the conclusions of these previous studies that topological and curvilinear-rectilinear relationships preceded understandings of Euclidean concepts.

The importance of topological concepts was further suggested when incorrect options were examined. For all vision categories and for both levels of school experience, option 2 (topologically similar shapes) was chosen more frequently than either of the other options. An encouraging note was that not only did young children make early distinctions on the basis of topological relationships, but also that this was true for all vision categories.

As with the study of objects (Simpkins, 1978b), the younger subjects typically used little examination of a shape's contour while the older subjects became more accurate. Davidson (1972) cited Gibson when he stated that the 6 to 7 year olds simultaneously grasped the whole figure with all fingers of the hand, isolating leading features of the form and appearing to compare it with all other aspects of the shape. It was concluded that simultaneous exploration was a particular aspect of active handling that bore upon the accuracy of judgment of the form. In the present study the experimenter noted young children would pinch a shape between the thumb and fingers of one hand, put a finger through a hole in the disk, or wear the closed ring as a bracelet which accentuated the topological features. The older subjects would frequently hold the shape in the palm of one

hand while feeling the contour with the fingers of that hand or by tracing the shape with a finger from the other hand. Davidson (1972) felt that exploratory activity may be modified by experience, but Swallow (1973) and Swallow and Poulsen (1972) concluded that the blind child may need to be taught how to trace edges and how to feel the entire surface in order to construct any image at all. It may be inferred from the present study, as Davidson (1972) suggested, that experience develops exploratory techniques since subjects with 1 year of school experience in general surpassed the performance of those with no previous schooling.

Since no significant differences were found between sexes or vision categories, it may be concluded that since development of elementary spatial concepts proceeds similarly, any differences which might be found subsequently must be attributed to other variables. One not explored in the present study, but inferred was age. Larendeau and Pinard (1970) did find a developmental trend based on age in their study of 2 to 12 year olds. Other variables that might be included would be intelligence and/or socioeconomic levels (Bass, 1975, pp. 45-70). One variable that would be of especial importance for visually impaired youngsters would be the effect of early training on active handling. Early training in exploratory techniques has been suggested as useful in training young blind children to isolate distinctive components, discriminate likenesses and differences, and provide a means for mental reconstruction of the stimulus (Swallow,

1973; Swallow & Poulsen, 1972; Tobin, 1972). The effects of this early training, if successful, could influence development of spatial concepts as well as later performance in spatial areas of life including such skills as orientation, mobility, and map reading and interpretation.

Footnote

Dr. Simpkins was an educational research scientist at the American Printing House for the Blind when this study was conducted. Presently, she is assistant professor in educational psychology at Brigham Young University.

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Table 1

Sample Distribution for Tactual Discrimination of Shapes Study

N = 48

	No previous schooling ages 4 to 7 years		1 year previous schooling ages 4 to 7 years	
No useful vision (blind)	M	4	M	4
	F	4	F	4
Some useful vision (partially sighted)	M	4	M	4
	F	4	F	4
Useful vision (sighted)	M	4	M	4
	F	4	F	4
		24		24

Table 2

t-Test Comparisons between Ages in Months of Tactual Discrimination of Shapes Study Subsamples

	0 years previous schooling		1 year previous schooling	
	M	*t*	*M*	*t*
Blind	69.13		73.13	
Partially sighted	67.38	.26	76.63	.61
Blind	69.13		73.13	
Sighted	66.00	.83	75.00	.37
Partially sighted	67.38		76.63	
Sighted	66.00	.25	75.00	.53

Table 3

Mean Total Correct Responses by Subsample on

Topological Shapes Assessment

		0 yrs. schooling ages 4 to 7 years		1 yr. schooling ages 4 to 7 years		Total by vision	
		M	SD	M	SD	M	SD
Blind	M	17.00	4.97	20.00	1.41	17.68	4.54
	F	20.25	1.25	13.50	5.92		
Partially sighted	M	15.50	4.51	22.25	1.26	18.40	3.61
	F	17.50	2.64	18.50	2.08		
Sighted	M	16.25	1.26	20.25	3.09	18.25	3.96
	F	13.75	1.50	22.75	.50		
Total by schooling		16.70	3.41	19.54	4.07		
Total by	M	18.54	3.74				
	F	17.70	4.25				

Table 4

ANOVA on Mean Total Correct Responses on

Topological Shapes Assessment

N = 48

Source	SS	df	MS	F
Vision (A)	3.29	2	1.65	.16
Schooling (B)	102.08	1	102.08	10.22**
Sex (C)	6.75	1	6.75	.68
A x B	137.54	2	68.77	6.89**
A x C	3.87	2	1.98	.19
B x C	33.33	1	33.33	3.34
A x B x C	110.29	2	55.15	5.52**
Error	359.50	36	9.99	

**$p < .01$

Table 5

Total Correct Responses for Each Shape by Subsamples for Part A of Topological Shapes Assessment

		N = 24												N = 24											
		0 years schooling ages 4 to 7 years												1 year schooling ages 4 to 7 years											
Item number		1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12
Blind	M	4	2	2	2	3	2	4	3	4	2	3	3	4	4	4	3	4	1	4	4	4	4	3	3
	F	3/7	2/4	1/3	3/5	4/7	4/6	4/8	4/7	3/7	3/5	4/7	4/7	2/6	2/6	3/7	2/5	3/7	2/3	4/8	2/6	3/7	2/6	2/5	3/6
Partially Sighted	M	3	3	1	2	2	3	2	3	3	2	3	3	3	4	3	4	4	4	4	4	4	4	4	4
	F	4/7	2/5	3/4	4/6	4/6	2/5	-/2	3/6	3/6	3/5	3/6	4/7	3/6	4/8	1/4	2/6	3/7	4/8	4/8	4/8	2/6	3/7	3/7	4/8
Sighted	M	1	2	2	1	4	4	4	2	3	4	4	3	3	2	2	2	4	4	4	4	4	4	4	3
	F	3/4	4/6	-/2	2/3	2/6	4/8	3/7	2/4	4/7	2/6	1/5	2/5	4/7	4/6	4/6	3/5	4/8	4/8	4/8	4/8	4/8	4/8	4/8	4/7
Total		18	15	9	14	19	19	17	17	20	16	18	19	19	20	17	16	22	19	24	22	21	21	20	21

Table 6

Total Correct Responses for Each Shape by Subsamples for Part B of Topological Shapes Assessment

		N = 24 0 years schooling ages 4 to 7 years												N = 24 1 year schooling ages 4 to 7 years											
Item number		1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12
Blind	M	3	2	3	4	3	3	2	1	3	2	4	4	3	2	3	4	3	4	4	2	2	3	4	4
	F	4/7	2/4	4/7	3/7	4/7	3/6	4/6	3/4	3/6	4/6	4/8	4/8	2/5	1/3	2/5	2/6	4/7	1/5	2/6	1/3	3/5	3/6	1/5	4/8
Partially sighted	M	2	2	2	1	4	2	4	3	2	3	4	3	4	3	4	4	4	4	4	1	3	4	4	4
	F	4/6	2/4	4/6	4/5	3/7	1/3	4/8	2/5	2/4	2/5	4/8	3/6	2/6	2/5	3/7	3/7	4/8	3/7	3/7	2/3	4/7	3/7	4/8	4/8
Sighted	M	2	2	4	3	3	2	3	-	2	3	4	3	4	4	4	3	4	4	3	2	1	4	4	4
	F	1/3	-/2	4/8	3/6	2/5	1/3	3/6	2/2	2/4	2/5	3/7	3/6	4/8	3/7	4/8	4/7	4/8	4/8	4/7	2/4	1/5	4/8	3/7	4/8
Total		16	10	21	18	19	12	20	11	14	16	23	20	19	15	20	20	23	20	20	10	17	21	20	24

Table 7

Items Arranged in Order of Difficulty

PART A

0 years schooling	item number	3	4	2	10	7	8	1	11	5	6	12	9
	number of correct responses	9	14	15	16	17	17	18	18	19	19	19	20
1 year schooling	item number	4	3	1	6	2	11	9	10	12	5	8	7
	number of correct responses	16	17	19	19	20	20	21	21	21	22	22	24

PART B

0 years schooling	item number	2	8	6	9	1	10	4	5	7	12	3	11
	number of correct responses	10	11	12	14	16	16	18	19	20	20	21	23
1 year schooling	item number	8	2	9	1	3	4	6	7	11	10	5	12
	number of correct responses	10	15	17	19	20	20	20	20	20	21	23	24

Table 8

Relative Difficulty of Items for Present Subsamples Compared with the Larendeau and Pinard Sample (1970)

Part A

	Larendeau & Pinard	Blind 0 year	Blind 1 year	Partially sighted 0 year	Partially sighted 1 year	Sighted 0 year	Sighted 1 year
	4	3	6	7	3	3	4
	8	2	4	3	1	4	2
Hardest	2	4	11	2	4	1	3
	12	10	1	6	9	8	1
	1	6	2	10	5	11	12
	6	1	8	4	10	12	5
	3	5	10	5	11	2	6
	11	8	12	8	2	5	7
	9	9	3	9	6	10	8
	10	11	5	11	7	7	9
Easiest	5	12	9	1	8	9	10
	7	7	7	12	12	6	11

Part B

	6	2	2	6	8	2	8
Hardest	2	8	8	2	2	8	9
	8	6	1	9	1	1	2
	4	7	3	4	3	6	4
	9	9	6	8	4	9	7
	10	10	9	10	6	5	11
	1	1	11	1	7	10	1
	5	3	4	3	9	4	3
	3	4	7	12	10	7	5
Easiest	7	5	10	5	5	12	6
	12	11	5	7	11	11	10
	11	12	12	11	12	3	12

Note. Item numbers are used for rankings.

Table 9

Number of Incorrect Options Chosen by Vision and Schooling Subsamples for Part A

Item number	0 years schooling									1 year schooling								
	Option 2			Option 3			Option 4			Option 2			Option 3			Option 4		
	B	PS	S	B	PS	S	B	PS	S	B	PS	S	B	PS	S	B	PS	S
1		1	2	1		2				1	1		1	1				1
2	3	2	2				1	1				2	2					
3	4	4	5	1					1	1	3	2		1				1
4	3	1	4			1		1		3	2	3						
5	1				1	1		1	1		1					1		1
6	1	1			1		1	1		2			2			1		
7		4				1		2										
8	1	2	2			2				1			1					
9	2	1			1	1				1				2				
10	1	1	1	2	2	1				1	1		1					
11		1	3				1	1		1	1		1			1		
12	1	1	3							1			1					1
Totals	17	19	22	4	5	9	3	7	2	12	9	7	9	4	0	3	0	4

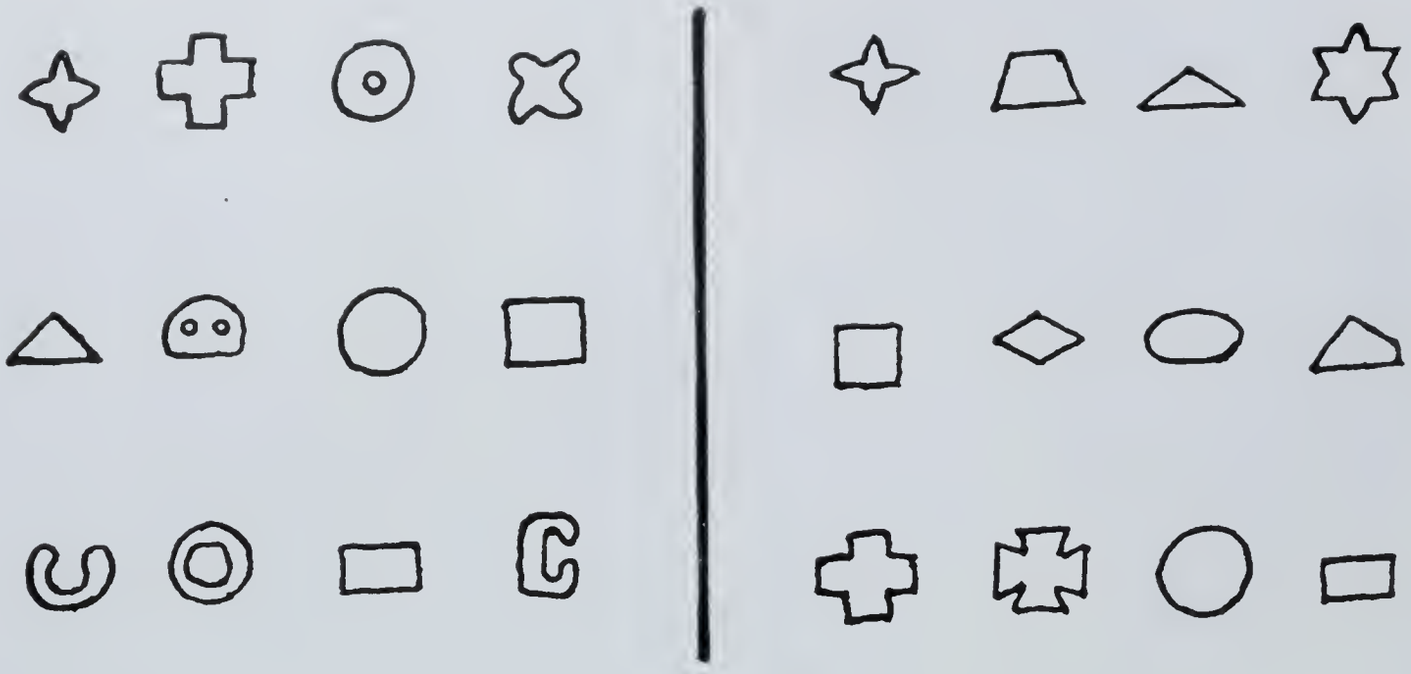
Table 10

Number of Incorrect Options Chosen by Vision and Schooling Subsamples for Part B

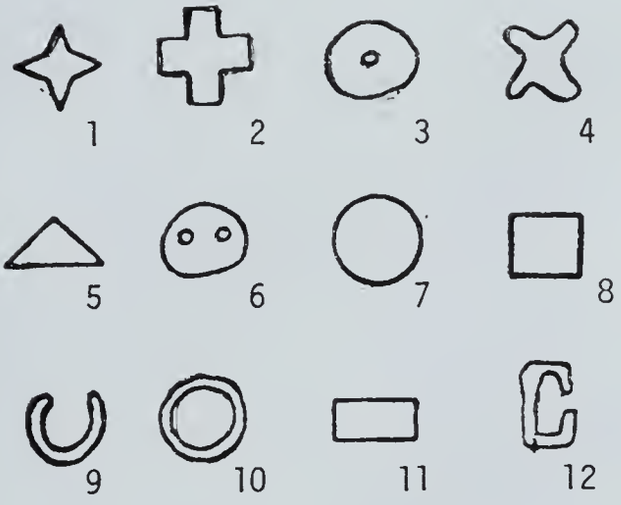
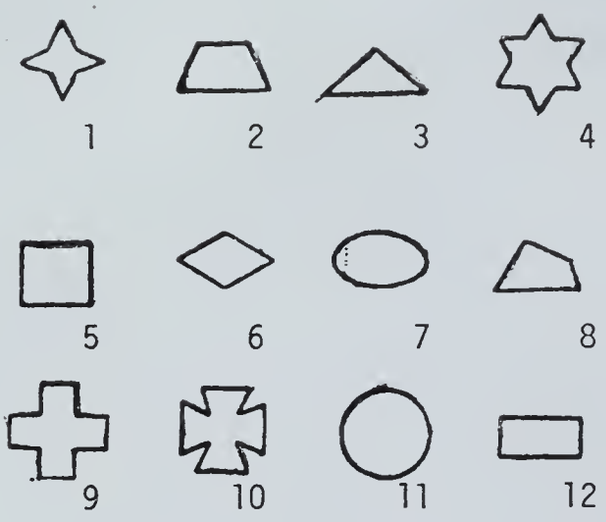
Item number	0 years schooling									1 year schooling								
	Option 2			Option 3			Option 4			Option 2			Option 3			Option 4		
	B	PS	S	B	PS	S	B	PS	S	B	PS	S	B	PS	S	B	PS	S
1	1		3			2		2		1			1				2	
2	2	1	1	1	1	1	1	2	4	3	3	1	1			1		
3		1					1	1		2			1				1	
4	1	2				1		1	1	2	1	1						
5	1		1		1	2							1					
6	1	4	2		1	2	1		4	3	1							
7	1		2				1				1	1	1			1		
8	2	2	4	1	1	2	1			4	3	3		2	1			
9	2	3	4		1					3	1	3						
10	1		1		3	2	1				1		1			1		
11			1							1		1	1			1		
12		1	1		1				1									
Totals	12	14	20	2	9	12	6	6	10	19	11	10	7	2	1	4	3	0

Figure Captions

Figure 1. Topological shapes assessment items.



Part A



Part B